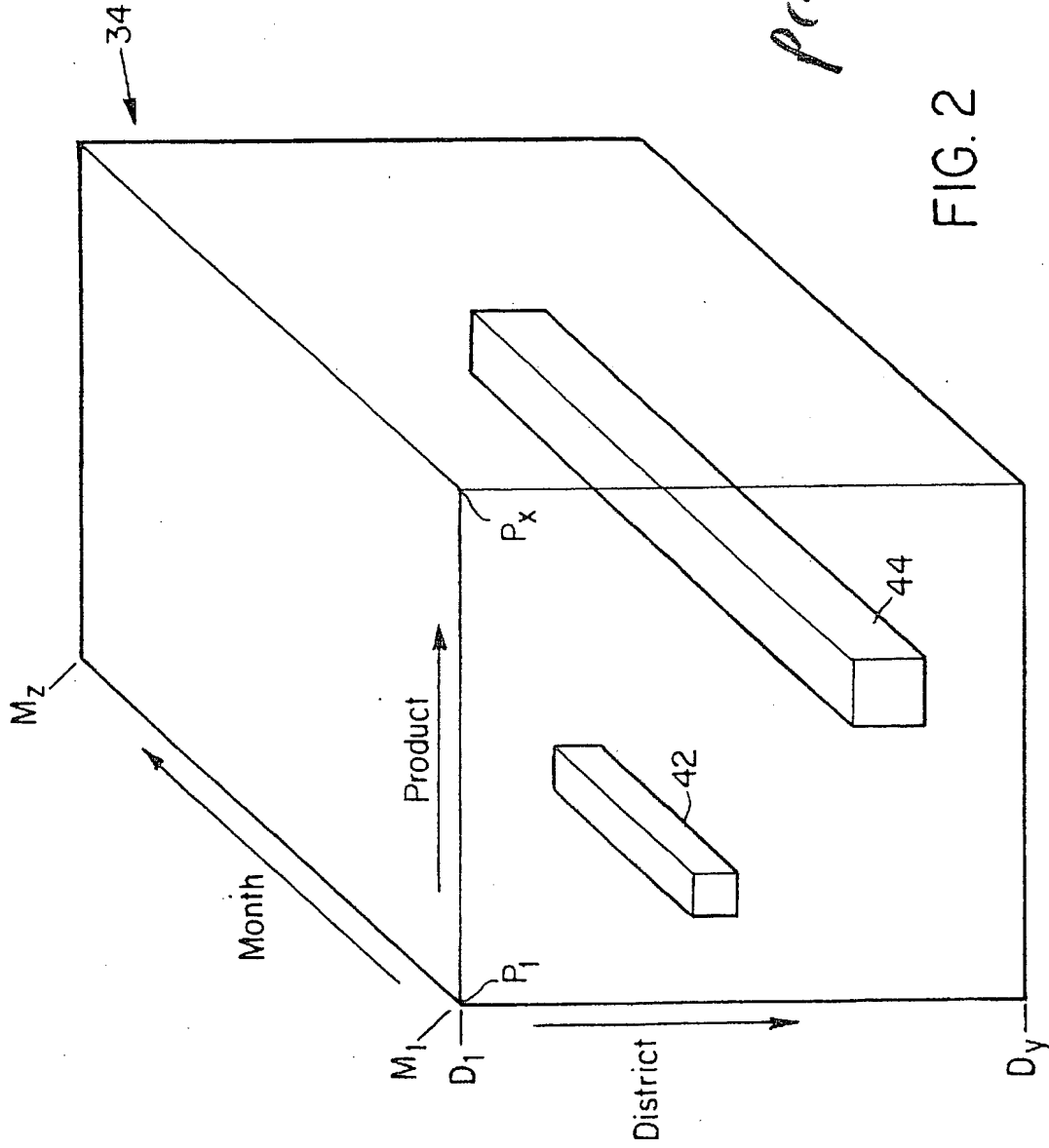


FIG. 1



Prior Art

FIG. 2

FIG. 3A

Prior Art

FIG. 3B

FIG. 3B

Prior Art

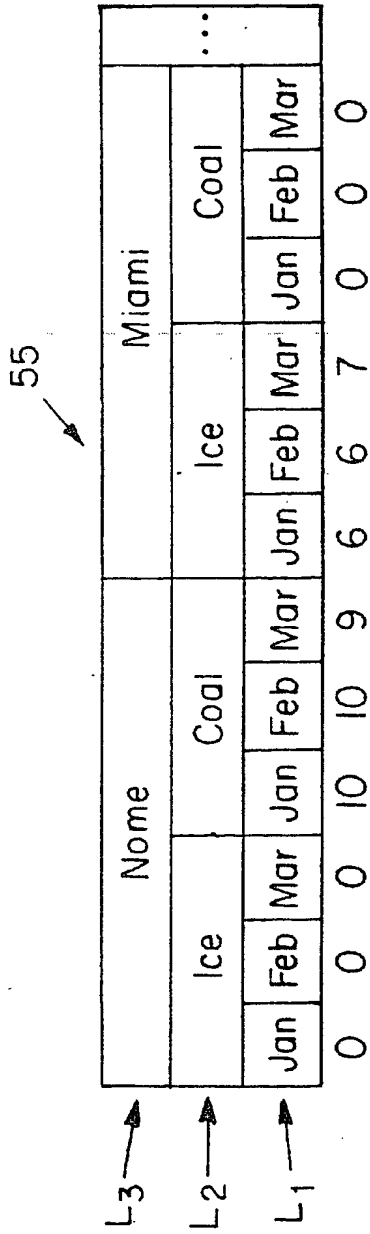
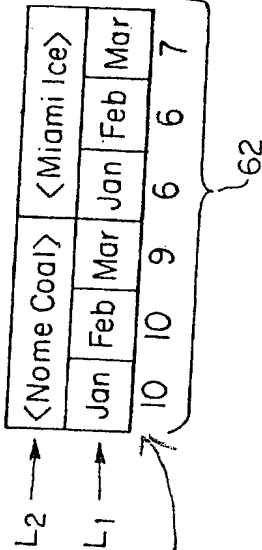


FIG. 4

Prior Art

70

OFFSET=0
 $N_{fast} = 3$
 $I_{slow}(\langle \text{Nome Coal} \rangle) = 0$
 $I_{slow}(\langle \text{Miami Ice} \rangle) = 1$
 $I_{fast}(\text{Jan}) = 0$
 $I_{fast}(\text{Feb}) = 1$
 $I_{fast}(\text{Mar}) = 2$



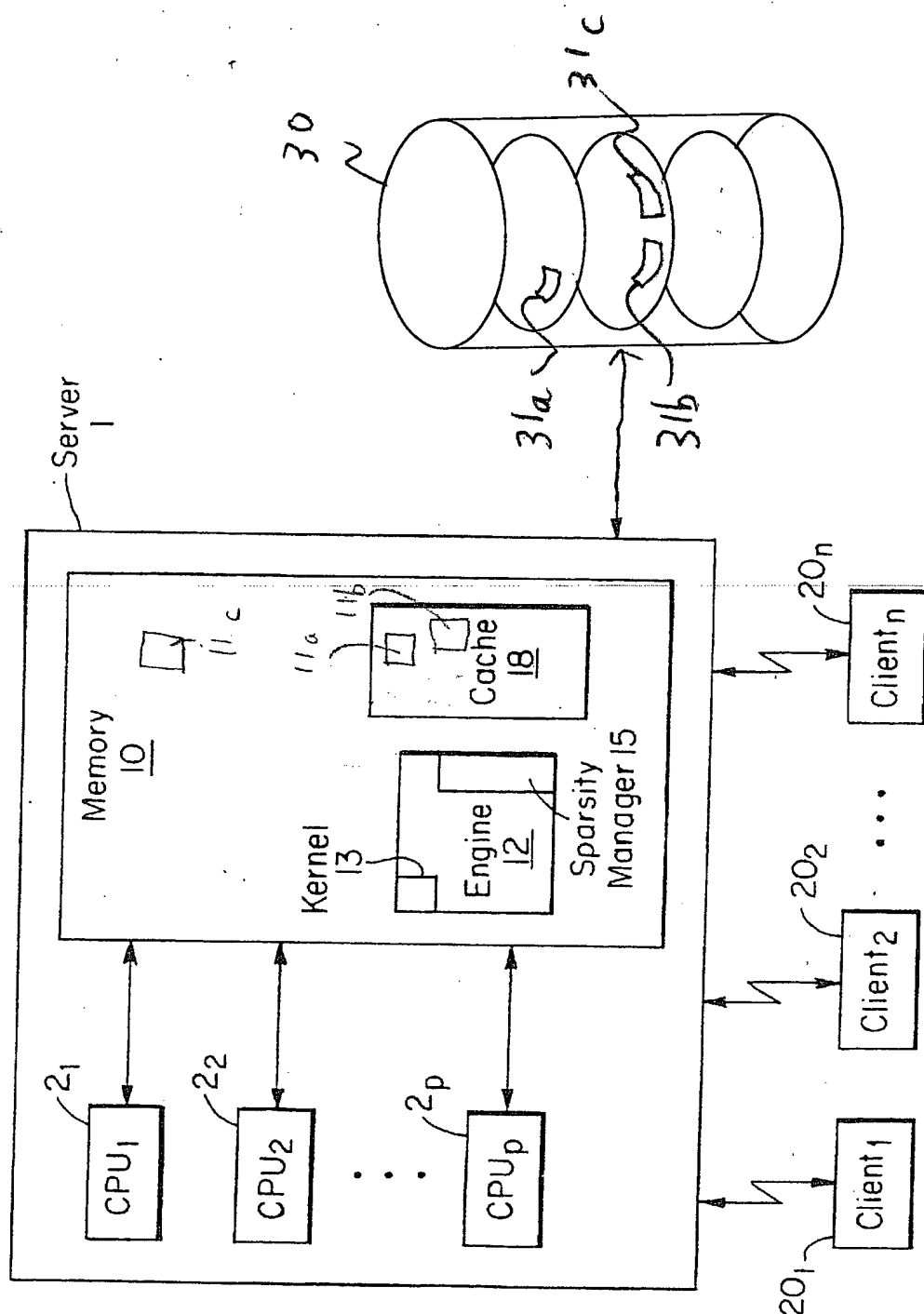


Fig. 6

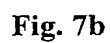
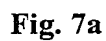


Fig. 8a

Fig. 8b

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graph TD
    100[Identify sparse dimensions] --> 102[Establish iteration for each of the sparse dimensions]
    102 --> 104[Retrieve the hierarchy of associated attributes]
    104 --> 106[Identify levels defined by the hierarchy]
    106 --> 108[Attempt fetch of data values associated with an aggregate value]
    108 --> 110[Index values from cache]
    110 --> 111{Cache hit?}
    111 -- Yes --> 112[Retrieve data values from the cache]
    111 -- No --> 114[Fetch corresponding storage segments from storage device]
    112 --> 116[Aggregate associated data values to determine aggregate value]
    114 --> 116
    116 --> 118{More data values on current level?}
    118 -- Yes --> 116
    118 -- No --> 120{Current dimension aggregated?}
    120 -- Yes --> 116
    120 -- No --> 102

```

Fig. 9

Y

Sales	Volume	Position
V (Bos, Jan)	=7	(1)
V (Bos, Feb)	=7	(2)
V (Bos, Mar)	=6	(3)
V (Bos, Apr)	=4	(4)
V (Bos, May)	=2	(5)
V (Bos, Jun)	=0	(6)
V (Nome, Jan)	=10	(7)
V (Nome, Feb)	=10	(8)
V (Nome, Mar)	=9	(9)
V (Nome, Apr)	=7	(10)
V (Nome, May)	=3	(11)
V (Nome, Jun)	=0	(12)
V (Bos, Q1)	V (Bos,Jan) + V (Bos,Feb) + (Bos,Mar) = 7 + 7 + 6 = 20	(13)
V (Bos, Q2)	V (Bos, Apr) + V (Bos, May) + V (Bos, Jun) =4 + 2 + 0 = 6	(14)
V (Nome, Q1)	V (Nome,Jan) + V (Nome,Feb) + (Nome,Mar) = 10 + 10 + 9 = 29	(15)
V (Nome, Q2)	V (Nome, Apr) + V (Nome,May) + V (Nome, Jun) = 7 + 3 + 0 = 10	(16)
V (Bos, 1 st half '00)	V (Bos,Q1) + V (Bos,Q2) =20 +6 =26	(17)
V (Nome, 1 st half)	V (Nome, Q1) + V (Nome, Q2) = 29 + 10 = 39	(18)

Fig. 10a

40 42 44

Sales	Volume	Position
V (E, Jan)	V (Bos, Jan) + V (Miami, Jan) =7 +0 = 7	(19)
V (E, Feb)	V (Bos, Feb) + V (Miami, Feb) =7 +0 = 7	(20)
V (E, Mar)	V (Bos, Mar) + V (Miami, Mar) =6 +0 = 6	(21)
V (E, Apr)	V (Bos, Apr) + V (Miami, Apr) =4 +0 = 4	(22)
V (E, May)	V (Bos, May) + V (Miami, May) =2 +0 = 2	(23)
V (E, Jun)	V (Bos, Jun) + V (Miami, Jun) =0 +0 = 0	(24)
V (W, Jan)	V (Nome, Jan) + V (LA, Jan) =10 +0 = 10	(25)
V (W, Feb)	V (Nome, Feb) + V (LA, Feb) =10 +0 = 10	(26)
V (W, Mar)	V (Nome, Mar) + V (LA, Mar) =9 +0 = 9	(27)
V (W, Apr)	V (Nome, Apr) + V (LA, Apr) =7 +0 = 7	(28)
V (W, May)	V (Nome, May) + V (LA, May) =3 +0 = 3	(29)
V (W, Jun)	V (Nome, Jun) + V (LA, Jun) =0 +0 = 0	(30)

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Fig. 10b

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Sales	Volume	Position
V(E, Q1)	$= V(\text{Bos}, Q1) + V(\text{Miami}, Q1)$ $= 20 + NA = 20$	(31)
V(E, Q2)	$= V(\text{Bos}, Q2) + V(\text{Miami}, Q2)$ $= 6 + NA = 6$	(32)
V(W, Q1)	$= V(\text{Nome}, Q1) + V(\text{LA}, Q1)$ $= 29 + NA = 29$	(33)
V(W, Q2)	$= V(\text{Nome}, Q2) + V(\text{LA}, Q2)$ $= 10 + NA = 10$	(34)
V(E, 1 st half)	$= V(\text{Bos}, 1^{\text{st}} \text{ half}) + V(\text{Miami}, 1^{\text{st}} \text{ half})$ $= 26 + NA = 26$	(35)
V(W, 1 st half)	$= V(\text{Nome}, Q1^{\text{st}} \text{ half}) + V(\text{LA}, 1^{\text{st}} \text{ half})$ $= 39 + NA = 39$	(36)
V(US, Jan)	$= V(\text{E}, \text{Jan}) + V(\text{W}, \text{Jan})$ $= 7 + 10 = 17$	(37)
V(US, Feb)	$= V(\text{E}, \text{Feb}) + V(\text{W}, \text{Feb})$ $= 7 + 10 = 17$	(38)
V(US, Mar)	$= V(\text{E}, \text{Mar}) + V(\text{W}, \text{Mar})$ $= 6 + 9 = 15$	(39)
V(US, Apr)	$= V(\text{E}, \text{Apr}) + V(\text{W}, \text{Apr})$ $= 4 + 7 = 11$	(40)
V(US, May)	$= V(\text{E}, \text{May}) + V(\text{W}, \text{May})$ $= 2 + 3 = 5$	(41)
V(US, Jun)	$= V(\text{E}, \text{Jun}) + V(\text{W}, \text{Jun})$ $= 0 + 0 = 0$	(42)
V(US, Q1)	$= V(\text{E}, Q1) + V(\text{W}, Q1)$ $= 20 + 29 = 49$	(43)
V(US, Q2)	$= V(\text{E}, Q2) + V(\text{W}, Q2)$ $= 6 + 10 = 16$	(44)
V(US, 1 st half)	$= V(\text{E}, 1^{\text{st}} \text{ half}) + V(\text{W}, 1^{\text{st}} \text{ half})$ $= 26 + 39 = 65$	(45)

Fig 10c

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V (Bos, Jan)	=7	(1)
V (Bos, Feb)	=7	(2)
V (Bos, Mar)	=6	(3)
V (Bos, Apr)	=4	(4)

V (Bos, May)	=2	(5)
V (Bos, Jun)	=0	(6)
V (Nome, Jan)	=10	(7)
V (Nome, Feb)	=10	(8)

V (Nome, Mar)	=9	(9)
V (Nome, Apr)	=7	(10)
V (Nome, May)	=3	(11)
V (Nome, Jun)	=0	(12)

V (Bos, Q1)	=20	(13)
V (Bos, Q2)	=6	(14)
V (Nome, Q1)	=29	(15)
V (Nome, Q2)	=10	(16)

V (Bos, 1 st half '00)	=26	(17)
V (Nome, 1 st half '00)	=39	(18)

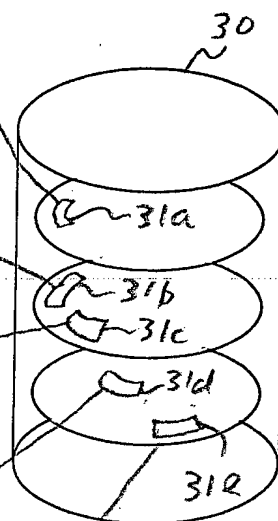


Fig. 11